SP-6005
CMO 19-000-1

OFFICE OF MANNED SPACE FLIGHT

APOLLO PROGRAM

ELECTRICAL POWER MANAGEMENT STANDARD

JUNE 15, 1965

N65-27944 (ACCESSION NUMBER) 34 (PAGES) (THRU) 1 (CODE) 11 (CATEGORY) (NASA CR OR TMX OR AD NUMBER)
FACILITY FORM 602

GPO PRICE $ _____
CFSTI
OTS PRICE(S) $ 2.00
Hard copy (HC) 1
Microfiche (MF) .50

PREPARED BY

PERFORMANCE ANALYSIS AND CONTROL
CONFIGURATION MANAGEMENT

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
WASHINGTON, D.C. 20546

ELECTRICAL POWER MANAGEMENT STANDARD

June 15, 1965

Performance Analysis and Control
Configuration Management
National Aeronautics and Space Administration
Washington, D.C. 20546

INDEX

ELECTRICAL POWER MANAGEMENT STANDARD

1. SCOPE ~~25~~ 27944

1.1 This document establishes a system for the management of electrical power source, load, and distribution properties during procurement and use of space vehicles or portions thereof. It is designed to permit the acquisition of systematized, verifiable, and controllable electrical power properties of vehicle systems and to facilitate rapid establishment and reporting of inputs for the source/load relationship. AUTHOR

1.2 The procuring activity shall, when necessary, specify all or part of this standard in contracts for portions of launch vehicles or spacecraft when such contracts are let directly by the procuring activity.

2. DEFINITIONS

2.1 Acquisition Phase. - The period in which full scale development (including testing) is accomplished. The Acquisition Phase ends when development and testing activity are no longer significant, and when updating change are on contract.

2.2 Component. - This term, as used herein, is synonomous with the common term "black-box." Component refers to a single Source, Load, Converter, or Regulator.

2.3 Contract End Item. - An item of contract complete within itself.

2.4 Converter. - Accepts electrical power at input voltage and frequency, converts it, and provides as output, electrical power at another voltage and/or frequency.

2.5 Critical Electrical Power Properties. - Any electrical power properties which have electrical power properties limits.

2.6 Definition Phase. - A formal period preceding full scale development (Acquisition Phase), during which preliminary engineering and contract management planning are accomplished.

2.7 Design Activity. - An agency having the responsibility for the design of the total vehicle or a portion thereof. A contractor, subcontractor or a division of a procuring activity may be a design activity.

2.8 Electrical Power Properties. - The characteristics of voltage, peak power, total power, frequency, power factor, and resistance or impedance referred both to power sources and loads, under conditions being considered in this document.

2.9 Electrical Power Requirements Growth. - The nominal predicted power allowance for design changes, within the design activity's work statement responsibility, used to arrive at the reported launch conditions from

current design data. Electrical power growth is an allowance which is historically justified and empirically determined. It is not treated as an uncertainty in dispersion studies, but may be subjected to uncertainty analyses when included as a part of a nominal Critical Electrical Power Property being so analyzed.

2.10 Improvement Potentials. - Alternate configurations or design changes which, when incorporated into the basic design, will result in improved electrical power characteristics.

2.11 Item. - The vehicle, or portion thereof, such as a stage, module, engine instrument unit, interstage, or contract end item.

2.12 Limiting Conditions. - Any system conditions to which any of the following apply:

a. Electrical power properties have been established by contract as the allowable limits for satisfaction of performance incentive or other system objectives.

b. Electrical power properties are decisively constrained by limiting values outside of which the mandatory system objectives or functions will not be achieved under the current design or operating characteristics.

c. Electrical power properties exercise a decisive influence upon the acceptable system objectives or functions under the current design or operating characteristics.

2.13 Manufacturing Variation. - A random uncertainty resulting from the predicted or calculated effects of manufacturing processes. It may be treated as an uncertainty in dispersion studies.

2.14 Mission Phase. - (Referenced on a given report or tabulation.) A portion of the mission during which a given row or column of the report or tabulation applies to the data reported.

2.15 Module. - An independent section of a vehicle.

2.16 Power Contingency. - The nominal power source capability allowance, for deficiencies in estimated or calculated power source capability data and load requirement data. Power contingency is a positive allowance which is historically justified and empirically determined. It is not treated as an uncertainty in dispersion studies, but may be subjected to uncertainty analysis when included as a part of a nominal Critical Electrical Power Property being so analysed.

2.17 Power System. - A combination of components consisting of a power source or several sources supplying a power distribution system; the power distribution system; all primary loads supplied by the power distribution system, including converters and regulators; and secondary distribution systems and loads supplied by converters and regulators.

2.18 Power System Identification. - Stage, module, or GSE, in which power system is located; and identification number which shall be used for all

components of the power system. (This may, for example, be a bus number for a system in which all components are connected to a single bus.)

2.19 Power System Mode. - Point on a power distribution system:
(a) to which any component is connected
(b) where any branches or forks in wiring are located
(c) where a connector connects two parts of the system
(d) where a contactor is located
(e) where a circuit breaker is inserted.

2.20 Precision. - The degree of agreement of repeated independent measurements of a single quantity, yielded by repeated applications of a measurement process under specified conditions.

2.21 Present Electrical Power Properties. - The latest electrical power property data derived from design data; excludes growth factors.

2.22 Procuring Activity. - Any agency which maintains administrative control of a contract entered into by the agency and design activity (contractor).

2.23 Random Error. - Error of a measurement method which fluctuates irregularly from observation to observation and which is caused by conditions that cannot be controlled completely.

2.24 Regulator. - Accepts electrical power at input voltage and voltage range. Accomplishes regulation to provide output voltage with reduced variation.

2.25 Stage. - An independent section of a vehicle.

2.26 Uncertainty. - A general term for the estimated amount by which the observed or calculated value of a quantity may depart from the value accepted as true.

3. REQUIREMENTS

3.1 General. - A system of electrical power management shall be established which is adequate to assure fulfillment of the program electrical power objectives. Qualified personnel shall be assigned the responsibility and authority to assure the establishment and maintenance of electrical power objectives, and the effective planning and execution of electrical power management functions, in accordance with the requirements of this document. The design activity shall be prepared to review with the procuring activity all submitted plans covering its technical organizational approach to electrical power management problems.

3.2 Electrical Power Objectives

3.2.1 Development of Objectives for the Acquisition Phase. - The primary purpose of all electrical power effort in the Conceptual and Definition

Phases shall be to develop achievable electrical source and load power objectives to be included in the System Specification for an Acquisition Phase. During the initial development of, or any subsequent change to, electrical power objectives, the design activity shall give particular attention to required substantiating analyses, in order to assist the procuring activity in specifying the objectives and their limitations.

3.2.2 Specified Electrical Power Base for Control and Reporting. - Unless otherwise directed by the procuring activity, electrical power objectives included in an approved System Specification shall constitute the Specified Electrical Power Base for control and reporting purposes at go-ahead for any phase. If an approved System Specification is not available at the time of go-ahead, electrical power specifications which are jointly coordinated and documented shall be treated as the Specified Electrical Power Base for control and reporting purposes, until a System Specification is approved.

3.3 Control

3.3.1 Planning. - Fulfillment of program objectives requires the procuring activity to have cognizance of the design activity's organizational and technical approaches to the electrical power management essentials of analysis, verification, improvement, reporting, and operational support in the field. The design activity shall prepare plans for such approaches in accordance with this document. All plans are subject to approval by the procuring activity.

3.3.2 Determination of Electrical Power Parameters

3.3.2.1 Design Monitoring. - The vehicle design, and the operating characteristics of electrical power sources, loads, regulators, converters, and distribution systems shall be analysed and monitored continuously to establish current electrical power properties, and to determine trend relationships with the Specified Electrical Power Base.

3.3.2.2 Design Sign Off. - All engineering drawings, procurement specifications, shop deviations, and other sources of change to components shall be signed, prior to release for manufacturing, by personnel responsible for the design activity's electrical power management effort. The signature shall verify that the electrical power properties of the components are correctly obtained, coded, and identified in the electrical power accounting system.

3.3.2.3 Uncertainty Analyses. - Analyses shall be conducted to ascertain the uncertainties of all Critical Electrical Power Properties to provide values for use in dispersion studies, to verify computed nominal values analytically, and to assist in idenfifying elements which warrant tests verification.

3.3.2.4 Limiting Condition Analyses. - Analyses shall be conducted for the purpose of assisting the procuring activity in establishing and

maintaining the contractual electrical power limits, and to establish other electrical power limits based on mandatory and acceptable system objectives and functions, under the current design and operating characteristics.

3.3.2.5 Verification of Critical Electrical Power Properties. - Each Critical Electrical Power Property and its conformance to limits shall be verified by the design activity. Verification is to be performed by approved analytical or experimental methods or by a combination thereof. The methods may be applied to the total Critical Electrical Power Property or to sub-element. Typical parameters requiring verification by analysis, or by acceptance, development, or other special tests, are nominal and dispersed values of the following:

a. Power source voltage vs. loading characteristics, as a function of operational life, total power drain, and other pertinent parameters
b. Converter output-input characteristics as a function of loading
c. Regulator output-input characteristics as a function of loading
d. Impedance of wiring, connectors, contractors, circuit breakers, and other elements of electrical power distribution systems.

3.3.2.6 Detail Electrical Power Properties Measurements. - Measurement programs for the determination of the actual characteristics of electrical power system elements shall be established. The measured data shall be used to verify and replace the calculated data in electrical power reports as the fabrication cycle progresses.

3.3.2.7 Contract End Item Electrical Power Properties Measurement. - At the time of test measurements of contract end item properties, or properties of major portions thereof, the item being measured shall simulate the flight condition as closely as possible. To the maximum extent practicable, combinations of elements shall be interconnected to form a complete electrical power system, and measurements shall be made in this condition. For loads, the actual voltage tolerence limits within which operation meets specifications shall be measured. For converters and regulators, the input-output characteristics shall be measured for the full range of loads between zero and full specification load. Complete data shall be measured on power sources where it can be demonstrated that this will not adversely affect service life or reliability. Where this is not the case, tests shall be devised which will provide the maximum confidence level of providing valid figures for the data required for the electrical power management program, without causing adverse effects. Impedance shall be measured for power distribution components, and actual operating currents of circuit breakers shall be measured.

3.3.2.8 Notification of Measurement. - In all cases of measurements to be performed in accordance with procuring activity approved procedures, the design activity shall notify the procuring activity of the time and place at least one week in advance.

3.3.2.9 Post-Flight Analyses. - Adequate instrumentation and procedures, subject to approval by the procuring activity, shall be provided to permit

post-flight analyses of the actual initial and terminal electrical power conditions of the flight. Post-flight analyses shall be performed to relate the planned conditions with those of the flight, and to relate the performance achieved to these conditions.

3.3.2.10 Field Support of Flight Operations. - The design activity shall plan and provide adequate electrical power systems support, subject to approval by the procuring activity, to flight operations in the field. This support shall maintain Critical Electrical Power inputs to flight planning which are in agreement with the actual vehicle configuration, and with conditions affecting the planned loading of sources and operation of loads.

3.3.3 Improvement Action

3.3.3.1 Means to Meet Specified Electrical Power Properties. - Electrical power management personnel, working with analytical and design personnel, and considering such governing criteria as reliability, performance, schedule, and cost, shall determine means to insure that specified electrical power properties are met or bettered.

3.3.3.2 Improvement Potentials. - A summary of all improvement potentials which could be used to offset electrical power properties or performance degradation shall be maintained and reported. Electrical power analyses for all alternative design configurations shall be included in the documentation.

3.3.3.3 Problem Definition. - The procuring activity shall be notified immediately of any problem requiring improvement action, with a statement of the problem and the potential effect of electrical power properties and performance when:

a. Program objectives are endangered.
b. Established control parameters have been reached or exceeded.

3.3.3.4 Corrective Action. - The design activity shall take, or recommend to the procuring activity, actions which will correct the recognized deficiencies.

3.4 Documentation. - Reports shall be submitted in accordance with this document, unless otherwise specified by the procuring activity.

3.4.1 Types of Reports Required. - The required reports are described by the following general types. Their specific composition is set forth in Sections 3.4.2 and 3.4.3 and may vary according to the phase of procurement.

3.4.1.1 Detail Electrical Power Reports. - Reports in this category provide comprehensive detail documentation of the electrical power properties. Vehicles or vehicle blocks reported upon shall be those specified by the procuring activity.

3.4.1.2 Electrical Power Status Reports. - Reports in this category provide a present status of the electrical power systems, of changes since the last report, and of problems encountered and progress made in tasks associated

with the electrical power management program. Vehicles or vehicle blocks reported upon shall be those specified by the procuring activity.

3.4.1.3 Procedural Reports. - Reports in this category provide outlines of the design activity approach for satisfying the requirements of this document. Initial submittals occur sufficiently in advance of implementation to permit their review and approval.

3.4.1.4 Miscellaneous Reports. - Submittal dates for the following reports in this category cannot be specified in this document.

3.4.1.4.1 Contract Changes Proposals. - Information to evaluate and substantiate the effect on vehicle electrical power properties from proposed changes. Submittal occurs with the Change Proposal.

3.4.1.4.2 Test Results. - Results of testing to verify parameters for the electrical power system elements submitted in accordance with the design activity's Electrical Power Properties Verification Plan.

3.4.2 Report Composition

3.4.2.1 General. - This section establishes the minimum content requirements for the various reports called for under the submittal schedule set forth in Section 3.4.4.

3.4.2.1.1 Forms. - Report elements which require the use of forms shall employ forms similar to those illustrated in Appendix A.

3.4.2.1.2 Current Electrical Power Relationships. - The design activity shall report present electrical power summaries and details in a manner to facilitate rapid establishment of their relationship to present performance, design, and mission functions of the system.

3.4.2.2 Report Elements. - Reports shall be composed of the applicable elements listed in Table 1, page 15, and described in Section 3.4.3.

3.4.3 Description of Report Elements

3.4.3.1 Title Page. - The first page of each report shall be a title page containing the following information, as applicable:

a. Report number
b. Type of submittal
c. Vehicle flight number
d. Stage, module, or GSE
e. Applicable serial numbers
f. Date of issuance
g. Actual date of data reported
h. Design activity's name
i. Mission identification.

3.4.3.2 Table of Contents. - A table of contents shall follow the title page.

3.4.3.3 Introduction. - Summarize significant material contained in the report. References to substantiating documents, reports, correspondence, and other pertinent information shall be included.

Note: For reports containing an Electrical Power Summary, a concise management review tabulation shall be included, presenting the following as applicable:

a. Control Parameter, on a complete power system basis, including:
   1. Total source power available
   2. Total load power consumption
   3. Source peak power available
   4. Peak load power required.
b. Control Parameter Encroachment - for each current electrical property which has reached or exceeded its control parameter, specify the following.
   1. Control parameter and its associated limit
   2. Present nominal electrical value
   3. Accuracy or uncertainty of the present nominal value
c. Highlights of newly encountered problems.

3.4.3.4 Design Activity Electrical Power Management Organization. - Furnish organization charts and descriptive material to identify the key personnel responsible for electrical power management, their responsibilities, their relationship to other elements of the organization, and the percentage of their time devoted to the contract. This data, submitted for information only, will be for procuring activity's internal use.

3.4.3.4.1 Design Activity Electrical Power Management Plan. - All plans prepared in accordance with 3.1 shall be submitted to the procuring activity for approval.

3.4.3.5 Electrical Power Summary. - Provide data derived from present detail data. To provide a logical buildup to total gross figures, the following procedure will be used. The loads on each regulator or converter will be totaled. The required input power for each converter or regulator for this output power will be determined. The total of these input power figures will be added to that for the loads connected directly to the bus. The power losses in the wiring, connectors, contacts, circuit breakers, etc. will then be added to obtain the total power figure. This procedure will be followed for obtaining power by mission phase, for obtaining peak power, and for obtaining total watt hours. This information shall be reported on a form similar to Form 1, (Appendix A). The minimum acceptable amount of information reported shall be as follows:

a. Power System Identification - Identification of power system, and mode of operation, where applicable, such as Normal, Emergency, Ground Power, etc. For each power system, data shall be given for each applicable mode.
b. Information Code - Identifies the units of the quantitative information, and applicability to source or combined loads.
c. Specified Base Figure - Original specified base.

d. Procuring Activity and Government Furnished Equipment (GFE) Changes - Changes resulting from design changes initiated by the procuring activity, and over or under power properties of GFE. Identify as + or -.
e. Revised Specified Base - The algebraic sum of (c) and (d) above
f. Present - Most valid available present figure.
g. Changes from last present - Changes in present figures since last report. These changes shall be cross referenced to the change analysis element of the report. (Paragraph 3.4.3.7).
h. Percentage Breakdown of Present - Percent of present figures which is estimated, calculated, and actual.
i. Note Number - Reference numbers for explanatory notes, remarks, or change analysis reference.

3.4.3.6 Detail Electrical Power Data. - Provides a complete breakdown of the component's present electrical power properties. This data shall be prepared on separate forms suitable for the required information on power sources, power distribution systems, converters and regulators, and electrical power loads. Form 2, Parts I, II, III, IV, and V (Appendix A), with attached definitions and instructions, indicate suitable formats and the information required.

3.4.3.7 Change Analysis and Improvement Potentials

3.4.3.7.1 Electrical Power Change Analysis. - An explanation of significant changes in present electrical power data shall be reported on a form similar to Form 3 (Appendix A). All changes in Government Furnished Equipment electrical power requirements shall be identified and explained. Each change shall be cross-referenced to the Electrical Power Summary report. The minimum acceptable amount of information shall be as follows:

a. Note Number - Reference number corresponding to the note number in the Electrical Power Summary.
b. Component affected - Identifies specific component of Electrical Power System for which electrical data has changed.
c. Change, Total - Total change in electrical property for each component. (Peak power, watt-hours, voltage or frequency, impedance, etc. as applicable.)
d. Effective Point - Vehicle effectivity, as applicable.
e. Change, Contractor Responsibility - Change in electrical power resulting from contractor changes.
f. Change, Procuring Activity Responsibility - Change in electrical power resulting from changes requested by the Procuring Activity. In addition where the actual change differs materially from the authorized change, appropriate comments shall be included, calling attention to and indicating the magnitude of the differences in electrical power.
g. Remarks - Explanation of each change, with reference authority. Changes which result from reconciliation of predicted values with test results shall be fully identified.

3.4.3.7.2 Pending Electrical Power Change Analysis. - Each pending change in electrical power, of any significance, including contract change proposals, shall be reported on a form similar to Form 3 (Appendix A). Separate forms will be used to itemize the following categories of change:

a. Changes established subsequent to the basic report close-out date.
b. Corrective action changes recommended by the contractor to correct recognized deficiencies.
c. Other pending changes.

This report shall contain the following minimum information for each change: As listed in Paragraph 3.4.3.7.1, plus case number.

3.4.3.7.3 Summary of Improvement Potentials. - Tabulate all electrical power improvement potentials which could be used to offset degradations. Include identification or case number, and best estimates of effects on electrical power, schedule, costs, reliability, and effectivity. Indicate whether technical feasibility is established or requires further study. Items which have been rejected shall be accumulated, together with the reasons for rejection.

3.4.3.8 Unresolved Problems. - All problems that may affect the electrical power system shall be reported at the earliest possible time, including the electrical power system affected, action being taken, and an estimate of when the problem will be resolved.

3.4.3.9 Electrical Power Properties Substantiating Data. - Validate the reported values by including the analytical, statistical, or empirical methods used in their derivations. Where values are determined by an accumulation of separate equipment values, values shall be given for each component.

3.4.3.10 Government Furnished Equipment. - A separate tabulation of all GFE shall be prepared for each vehicle stage and module, and for GSE for each flight number, showing the drawing number and description, serial number where applicable, number required, and the component and total specified electrical power properties. Provisions shall be included to record the actual component and total power and the difference between total specified and total actual power.

3.4.3.11 Actual Electrical Power Properties Data Records. - Actual electrical power properties data records shall be provided for each major measurement performed in accordance with procedures approved by the procuring activity.

3.4.3.11.1 Records for all Measurements. - These records shall include the following for all such measurements:

a. Location where measurements were performed, signature of authorized individual responsible for the entries, date and time of entries, date of last equipment calibration, document number of the approved measuring procedures, and identification of the component measured.
b. Provision for the signature of a procuring activity witness on each page of the data record that includes measured data.

3.4.3.12 Evaluation of Flight. - Compare the actual launch electrical power properties, and the actual electrical power properties variations throughout the flight with the predicted electrical power properties flight data. An evaluation of the critical electrical power properties, uncertainties, and other pertinent data shall be included in the final post flight reports to substantiate electrical power properties contained in the design activity's Final Flight Evaluation Report. Quick look reports should be confined to gross information and analysis based on the best available sources to confirm either normal flight electrical power properties conditions or apparent anomalies.

3.4.3.13 Electrical Power Properties Limits. - Electrical power properties limits shall include the following:

a. A tabulation of the limiting conditions and the associated electrical power properties limits which are established by contract. Include reference to the contract document and page where the requirement is placed.
b. A tabulation of the limiting conditions and the associated electrical power properties limits which are established by mandatory and acceptable system objectives and functions under the current design and operating characteristics.
c. Analyses supporting and establishing the allowable limiting values of each electrical power property condition tabulated in (b) above.

3.4.3.14 Electrical Power Properties Verification Plan. - Identify critical electrical power properties, or elements thereof, for which experimental verification is proposed, and those for which experimental verification is not proposed. Justification shall be provided for both cases. Test plans shall be included for experimental measurements proposed. A guide for preparing the required information is given in Appendix B.

3.4.3.15 Operational Support Plan for R&D. - The operational support plan for research and development shall include the following:

a. Description of the procedures to be employed to determine and record the detail electrical power property changes resulting from field changes in configuration and from changes in operating conditions.
b. Description of the methods and channels through which detail electrical power property records of changes in the field are to be picked up, evaluated, and recapitulated for rapid pre- and post-flight reporting to the procuring activity and to other design activities as required.
c. A description, and the intended use, of applicable facilities and equipment for accomplishment of the above.
d. An outline of the organizational relationships between design activity organizations in the field and the home plant for assuring rapid response to and reporting of changes occurring in the field. The principal points of contact, in the field and at the home plant, shall be indicated to establish the means by which preliminary information of field-originated changes can be obtained.

3.4.3.16 Operational Support Plan for Orbital Phase. - This plan shall have as its objective the assurance that in-flight electrical power properties changes are adequately and promptly detected or determined during flight, and that any decision for in-flight change to mission performance objectives

may be obtained with the correct Critical Electrical Power Properties. The plan shall include an examination of contingencies which may logically cause significant deviations in electrical power characteristics; provisions for improving electrical power characteristics by emergency measures to reduce power consumption; and provisions for rapidly displaying results to the crew or controlling station.

3.4.4 Report Submittal Requirements

3.4.4.1 Schedule of Submittals. - Unless otherwise specified by the procuring activity, Table I constitutes the required submittal schedules for reports. The schedules reflect required dates for receipt of final design activity approved documents at the office of the procuring activity where technical management of the program resides. Where the interests of the program require, the design activity shall be prepared to provide supplemental data or informal inputs for any report in an expeditious manner.

3.4.4.2 Distribution. - Direct distribution is required to the organization which has technical electrical power property cognizance of the program, and to such other distribution as the procuring activity specifies.

3.4.4.3 Approvals. - Unless otherwise specified by this document, or the procuring activity, all reports are submitted for information only.

3.5 Subcontractor Surveillance. - The design activity shall be responsible for the adequacy of the electrical power properties management efforts of the subcontractors for their respective system. Where applicable, an electrical power properties section, comparable to and compatible with the requirements set forth in this document, shall be prepared and incorporated into each procurement specification.

3.6 Associate Design Activity and GFE Suppliers Interfaces. - Associate design activity and GFE suppliers shall be responsible for assuring that there is sufficient interchange of electrical power data to support the integration of subcomponent electrical power properties into the complete component electrical power properties and shall promptly respond to requests from their interfaces and integration design activities for information required by them in satisfaction of the requirements of this document.

4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for Inspection. - Unless otherwise specified in the contract or purchase order, the supplier is responsible for the performance of all inspection requirements as noted herein. Except as otherwise specified, the supplier may utilize his own facilities or any commercial laboratory acceptable to the Government. The Government reserves the right to perform any of the inspections set forth in the specification where such inspections are deemed necessary to assure supplies and services conform to prescribed requirements.

4.2 Inspection Methods

4.2.1 Examination. - The electrical power control data shall be thoroughly examined to determine conformance with this standard with respect to all the requirements noted herein.

4.2.2 Delivery. - The data package shall be examined to ascertain that the preparation for delivery conforms to this standard.

5. PREPARATION FOR DELIVERY

5.1 Preservation and Packaging

5.1.1 Level A. - The electrical power properties control data shall be preserved and packaged in accordance with Method IC of Specification MIL-P-116.

5.1.2 Level C. - Preservation and packaging shall be as stipulated in paragraph 5.1.1.

5.2 Packing

5.2.1 Level A. - Electrical power properties control data shall adequately be packed to meet the carriers' rules and regulations and to insure safe delivery at destination. Such packs shall meet security regulations when contents are classified. See paragraph 6.2.2.

6. NOTES

6.1 Intended Use. - The procuring activity will be continuously evaluating each design activity's electrical power control capability and effectiveness. The results of the evaluation will be summarized and documented, within the procuring activity, as frequently as conditions warrant; however, each design activity will be completely evaluated within six months after being awarded a contract and annually thereafter. These reports will be for Government internal use only and will not be provided for contractor information. The evaluation will be based upon, but not limited to, the following:

a. Trend relationship between design activity electrical power properties summaries and specified electrical power properties requirements.
b. Completeness of data submitted.
c. Compatability of measured data with estimated and calculated data.
d. Compliance with data submittal schedules.

6.2 Changes. - This standard will be reviewed for possible revision or reissuing whenever necessary, but not later than one year from the most recent date of review. The review will be conducted by Apollo Program Office, NASA Headquarters, Washington, D.C., who upon completion of the review shall issue all necessary revision and review date identification. Any standard bearing a review date older than one (1) year shall be considered void except for existing contracts. Recommendations for revising this standard may be made by any organization within the United States Government, and the aerospace industry. Recommended changes, when sub-

mitted, shall be completely documented, presenting just reasons for the revision and showing the benefit to both the NASA and the aerospace industries which may be derived from the revision. All recommended changes must be submitted not later than three months prior to the next scheduled review date if they are to be considered for incorporation into the next revision of the standard. All recommended changes shall be submitted to the Director, Apollo Program Control, Apollo Program Office, NASA Headquarters, Washington, D.C., 20546.

6.3 Information for Contracting Officer

6.3.1 Procurement Document. - Procurement documents should specify the following:

a. Title, number and date of this standard.

b. Selection of applicable levels of preservation, packaging, and packing required.

c. Items of data required (see paragraph 3).

d. Additional Quality Assurance provision as applicable.

6.3.2 Classified Data. - The applicable security regulations of the procuring activity shall control the processing and distribution of classified data.

Program Phase			Funded Studies (any phase)		Definition		Acquisition													
Report Type			Detail	Status	Detail	Status	Detail				Status						Procedural			Misc.
Column No.			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Schedule of Submittals			Semiannually for studies of 1 year or more; at completion of all studies	Every other week for studies of 2 months or less; at first of each month for studies of more than 2 months	Semiannually for studies of 1 year or more; at completion of all studies; with submittal of all proposals	Every other week for studies of 2 months or less; at first of each month for studies more than 2 months (to be continued through contract definition)	AT PDR, or within 30 days of approved definitive contract (FOR APPROVAL) (or Go-Ahead)	Annually for contracts exceeding 2 years	AT CDR, or within 30 days after 90% completion of original drawing release for contracts of less than 2 years	At FACI, or within 30 days after measurements, or flights, specified by the procuring activity	Design - first of each month after approved definitive contract (or Go-Ahead) and ending with delivery of last item	Pre-flight - 120 days prior to launch	Pre-flight - 14 days after acceptance testing	Pre-flight - 14 days after significant change	Post-flight - Quick Look - within 24 hours	Post-flight - Final - 30 days after launch	Verification Plan - within 6 months after definitive contract (or Go-Ahead) (FOR APPROVAL)	Operational Support Plan - R&D within 6 months after definitive contract (or Go-Ahead) (FOR APPROVAL)	Operational Support Plan - Orbital within 6 months after definitive contract (or Go-Ahead) (FOR APPROVAL)	Contract Change Proposal - with each contract change proposal
Report Element	(para)	Page																		
Title Page	3.4.3.1	7	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x		
Table of Contents	3.4.3.2	7	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Introduction	3.4.3.3	8	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Design Activity Electrical Power Management Organization	3.4.3.4	8	x		x		x	x	x	x										
Electrical Power Summary	3.4.3.5	8	x	x	x	x	x	x	x	x	x	x	x	x	x	x				
Detail Electrical Power Data	3.4.3.6	9	x		x		x	x	x	x	x	x	x	x	x	x				
Electrical Power Change Analysis	3.4.3.7.1	9	x	x	x	x	x	x	x	x	x	x	x	x	x	x				x
Pending Electrical Power Change Analysis	3.4.3.7.2	10		x	x	x	x	x	x	x	x	x	x	x	x	x				
Summary of Improvement Potentials	3.4.3.7.3	10		x	x	x	x	x	x	x	x	x	x	x	x	x				
Unresolved Problems	3.4.3.8	10		x	x	x	x	x	x	x	x	x	x	x	x	x				
Electrical Power Properties Substantiating Data	3.4.3.9	10	x		x		x	x	x	x										x
Government Furnished Equipment	3.4.3.10	10	x		x		x	x	x	x		x	x	x	x	x				
Records for all Measurements	3.4.3.11.1	10																		
Evaluation of Flight	3.4.3.12	11																		
Electrical Power Properties Limits	3.4.3.13	11	x	x	x	x	x	x	x	x	x	x	x	x	x	x				
Electrical Power Properties Verification Plan	3.4.3.14	11	x		x												x			
Operational Support Plan for R&D	3.4.3.15	11	x		x													x		
Operational Support Plan for Orbital Phase	3.4.3.16	11	x		x														x	

Table 1. Report Content and Submittal Schedule (Refer to paragraphs 3.4.1, 3.4.2, and 3.4.3)

APPENDIX A

REPORTING FORMS

ELECTRICAL POWER SUMMARY (Form I)

POWER SYSTEM IDENTIFICATION	INFOR-MATION CODE	SPECIFIED BASE FIGURE	PROCURING ACTIVITY AT GFE CHANGES	REVISED SPECIFIED BASE	PRESENT	CHANGE FROM LAST PRESENT	PERCENTAGE BREAKDOWN OF PRESENT			NOTE NUMBER
							EST	CALC	ACT	
	S-1	SOURCE WATT-HOURS								
	S-2	SOURCE PEAK POWER								
	L-1	COMBINED LOADS WATT-HOURS								
	L-2	COMBINED LOADS PEAK POWER								
	S-1									
	S-2									
	L-1									
	L-2									
	S-1									
	S-2									
	L-1									
	L-2									
	S-1									
	S-2									
	L-1									
	L-2									
	S-1									
	S-2									
	L-1									
	L-2									
	S-1									
	S-2									
	L-1									
	L-2									

VEHICLE ____________
STAGE ____________
MISSION ____________

PREPARED BY ____________
DATE ____________

REPORT NO. ____________
PAGE ________ OF ________

Power Source Analysis (Form 2 Part I)
Definitions and Instructions

1. Power Source : All sources which provide power to a given primary bus. (Battery; Fuel cell plus fuel, etc.)

2. Type : Source type designation.

3. Voltage : Shall be listed as "a to b," where "a" is the minimum specification voltage under rated load, and "b" is the maximum voltage under no-load conditions.

4. Amp-Hours Rating: Use specification rating figure.

5. Amp-Hours Budget: Total ampere hours which will be drawn from source during mission.

6. Peak Amps Rating: Rated full-load current on which "a" in (3) above is based.

7. Peak Amps Budget: Maximum current which will be drawn from source during mission.

8. Max. Internal Impedance: Rated internal impedance after source has delivered "Amp-Hours Rating" given in Item 4.

9. No. Units: Number of units of type included in Power Source.

10. Reference Specification: Purchase specification or other reference giving complete information on type

11. Phase and Phase Description: Identification of Mission Phase for which following data applies.

12. Time: Identify by a note the zero reference of the time scale used.

13. Units of Type: Number of units of each type supplying power to the bus during mission phase.

14. Load Amperes: Average and peak during mission phase.

15. Watt-Hours: Total for mission phase

16. Class: E. Estimated. Will be utilized during early design phase, and cannot be considered to have high confidence level.
    C. Calculated from design data. Will have higher confidence level than "E".
    A. Actual. Measured on Actual equipment.

POWER SOURCE ANALYSIS (Form 2 Part I)
Battery, Fuel Cell plus Fuel, or other Power Source

_____
(vehicle & S/N)

Power System Identification _____ Report No._____ Rev._____
Date_____

Bus_____
Dwg/No._____
Power Distribution System Nodes:

Unit	1	2	3	4
Supply				
Return				

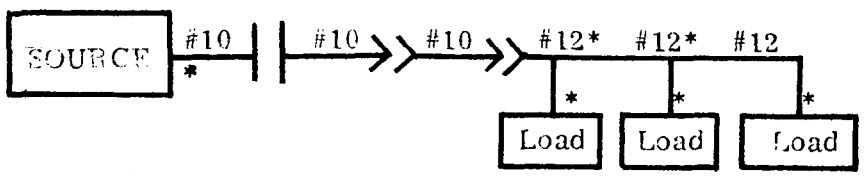
POWER SOURCE SPECIFICATION								
Type	Voltage	Amp-Hours Rating	Amp-Hours Budget	Peak-Amps Rating	Peak Amps Budget	Max. Internal Impedance	No. Units	Reference Specification
1								
2								
3								
4								

MISSION PHASE ANALYSIS												
	Phase Description	Time		Units of Type:				Load Amperes		Watt Hours	Class (E.C.A.), %	Notes
		Start	End	1	2	3	4	Average	Peak			

Electrical Power Distribution Information (Form 2 Part II)
Definitions and Instructions

1. Wire lengths and sizes. A node for the wire length and size listing will be determined by:
   a. Beginning or termination of wire at source or load
   b. Change in size of wiring
   c. Load branch

   Example:



*Nodes

2. Relay/Contactor Resistance Specification.

3. Connector Resistance Specification.
   Items 2 and 3 shall cover, for each contact and connector, the most valid available figure for maximum resistance of the contact or connector.

4. Source and load identification.
   This shall cover, for each source and load associated with a given Electrical Power Distribution System, sufficient data to identify it unambiguously.

5. Configuration by mission phase.
   This shall be a tabulation of the open or closed condition of all contacts by mission phase to specify the connection of source to busses, and of busses to loads by mission phase.

6. Voltage - Current characteristics of other power distribution components (Such as isolation diodes, circuit breakers, etc.).
   In most cases a figure for maximum resistance will suffice. In other cases, such as isolation diodes, a V-I curve will be required.

Electrical Power Distribution (Form 2 Part II)

Vehicle + S/N_____

E.P.D. System Identification_____

Attached: Electrical Power Distribution Diagram
with Following Information:

1. Wire lengths and sizes.
2. Relay/Contactor Resistance Specifications.
3. Connector Resistance Specifications.
4. Source and Load Identification.
5. Configuration by Mission Phase.
6. Voltage - Current characteristics of other power distribution components.

Electrical Power Converter/Regulator (Form 2 Part III)
Definitions and Instructions

1. Supply Bus: Power bus for converter or regulator

2. Load Bus: Bus which is powered by the output of converter or regulator

3. Input Volts: Range of voltage over which unit will perform within specifications

4. Input Amps: Input current drawn by unit when supplying rated output power

5. Output Volts: Specific voltage or range of voltage, whichever is applicable

6. Output Amps: Maximum rated output current

7. Frequency: Specific frequency or range of frequency, whichever is applicable

8. Elapsed Time: Identify by a note the zero reference for time scale used

9. Mission Phase:

10. Mission Sub-phase:

11. Watts Average - Average for Mission Phase (Supply & Output)
12. Watts Peak - Peak reached during Mission Phase (Supply & Output)

13. Power Factor - Average - Averaged over mission phase

14. Total Power - Totals by Mission Phase (Supply & Output)

15. Class:
    - E. Estimated. Will be utilized during early design phase and cannot be considered to have high confidence level
    - C. Calculated from design data. Will have higher confidence level than "E".
    - A. Actual. Measured on actual equipment

Note - The efficiency factor for each conversion/regulation component can be determined from the input/output power given.

ELECTRICAL POWER CONVERTER/REGULATOR (Form 2 Part III)

_____
(vehicle & S/N)

Power System Identification _____

_____System
_____Sub-system
Power System Nodes: Supply_____
Return_____

Type_____
Input Volte____to____
Input Amps_____

Output Volts___Freq._____
Output Amps (Max.)_____

Report No._____Rev._____
Date_____

Supply Bus_____
Dwg. No._____
Load Bus_____
Dwg. No._____

Total Energy Requirements for Mission_____Watt Hours
Total Energy Output for Mission_____Watt Hours

Elapsed Time	Mission Phase	SUPPLY POWER				OUTPUT POWER				Class (E.C.A),%	NOTES
		Watts Average	Watts Peak	Total Power Per Phase (Watt Hours)		Watts Average	Watts Peak	Power Factor-Average	Total Power Per Phase (Watt Hours)		

Electrical Load Analysis (Form 2 Part IV)
Definitions and Instructions

1. Present Watt Hrs. : Most valid available figure as of date of report of total watt-hours which will be consumed by component during mission.

2. Budgeted Watt Hrs. : Total mission watt-hours allocated for operation of component.

3. Present Watts (Peak): Most valid available figure of peak watts which will be drawn by component.

4. Budgeted Watts (Peak): Peak watts allocated for operation of component.

5. Volts: Range of voltage within which component will operate within specifications.

6. Frequency: Range of frequency within which component will operate within specifications.

7. Elapsed Time: Identify by a note zero reference of time scale used.

8. Mission Phase:

9. Mission Phase Watts Average: Average power drawn during phase.

10. Mission Phase Watts Peak: Peak watts drawn during phase.

11. Total Energy per phase: Total Watt-Hours consumed during phase.

12. Class:
    - E. Estimated. Will be utilized during early design phase, and cannot be considered to have high confidence level.
    - C. Calculated from design data. Will have higher confidence level than "E".
    - A. Actual. Measured on actual equipment.

13. Power Factor: Average power factor during phase.

14. Phase Name - Remarks: Descriptive identification of phase. Other pertinent information.

ELECTRICAL LOAD ANALYSIS (Form 2 Part IV)

_____
(vehicle & S/N)

Power System Identification _____

Power System Nodes: Supply_____ Unit_____
Return_____ Watt Hrs._____ Budgeted Watt Hrs._____ Report No._____Rev._____
Watts (Peak)_____ Budgeted Watts (Peak)_____ Date_____
Volts_____Frequency_____

Elapsed Time	Mission Phase	Mission Phase Watts Average	Mission Phase Watts Peak	Total Energy Per Phase (Watt Hours)	Class (E.C.A.) %	Power Factor	Phase Name/Remarks

Electrical Interference Data (Form 2, Part V)

For each component, the following information shall be provided

1. Maximum interference voltage which can be present on the input line without affecting component performance within specifications. Include data such as allowable transient voltage as a function of transient duration, allowable noise voltage as a function of frequency, etc.

2. Maximum interference current which the component will impress upon the power supply line, and characteristics of the current such as frequency, transient rise time and duration, etc.

3. For power sources, including primary sources, converters, and regulators, interference voltage component information.

Note 1: An interference component of voltage or current is a component at any frequency other than the specified supply frequency range, including noise, ripple, transients, etc.

Note 2: Radiated Electromagnetic Interference and Electromagnetic Interference field are not to be considered under this data requirement.

ELECTRICAL POWER CHANGE ANALYSIS (Form 3)

SUMMARY REPORT NO._____ PREPARED BY:_____

NOTE NO._____ DATE:_____

COMPONENT AFFECTED:_____ REPORT NO.:_____

_____ SHEET_____ OF _____

CHANGE, TOTAL_____

EFFECTIVE POINT_____

RESPONSIBILITY: CONTRACTOR_____ NASA_____

CASE NUMBER (FOR PENDING CHANGES) _____

****

REMARKS - CHANGE EXPLANATION AND ANALYSIS

APPENDIX B

ELECTRICAL POWER PROPERTIES VERIFICATION PLAN

GENERAL

This appendix is a guide for preparing the electrical power properties verification plan discussed in paragraph 3.4.3.14. The following items shall be included:

a. Analytical Verification Items
   1. Items to be verified by analysis
   2. Analytical substantiation that test is not required for these items

b. Experimental Verification Items
   1. Items to be verified by experiment
   2. Analytical substantiation that test is required for these items
   3. Estimated costs of proposed tests.

TEST PLAN

For each item to be tested, or for each block of tests, list the following:

a. Measurement objectives, including measurement to be performed and overall accuracy required.

b. Description of the test setup, including the location, measurement system proposed, equipment, fixtures, and environmental control provisions.

c. Measurement procedures, number of successful runs required, the use of average readings from a number of independent measurements, and the requirements for cycling of switching, recharging of sources, etc., between measurement readings.

d. Instrumentation calibration procedure and schedule.

e. Statement of overall uncertainty of the measurement system, with supporting analysis of the system showing calibration and systematic error analysis. The measurement system analysis shall indicate possible sources of random error, their method of estimation, and their possible effect on the precision of measurement, and shall show the method of combining different sources of error to obtain a value for overall uncertainty of the measurement process. The analysis also shall indicate the relationship of the uncertainty with the required accuracy.

f. Schedule, including equipment availability dates and test start and completion dates.

g. Test reporting plan, including submittal schedules, for reports containing the following minimum information:
   1. Explanation of deviations from test plan
   2. Summary of data
   3. Evaluation of results
   4. Final conclusion of results
   5. Recommendations.